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National Health & Environmental Effects Research Laboratory

Western Ecology Division

Research Update

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FRESHWATER ECOLOGY BRANCH

below: Northern Pike undergoes biopsy sampling; tissue sample will be tested for methylmercury

Since the late 1980's, there has been a downward trend in mercury emissions from manufacturing sources in the U.S. But according to WED's **Dr. Spencer Peterson,** mercury in stream fish tissue still exceeds the USEPA tissue based water quality criterion in several stream reaches across the Western U.S.

Mercury consumption via fish remains a concern for both humans and wildlife because of their Methylmercury (MeHg) content. Since 2002, Peterson has carried out a series of studies to assess the regional extent of the problem.

MeHg=MethylMercury

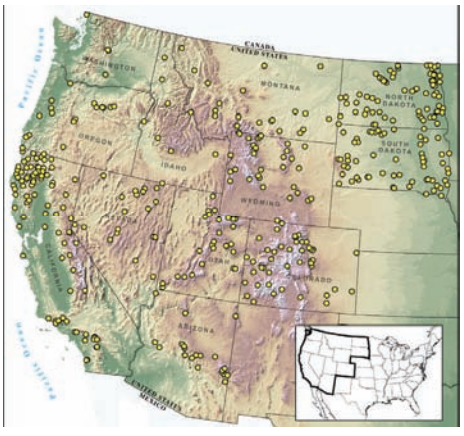
Large-scale combustion of fossil fuels like coal release tons of mercury (Hg) into the atmosphere. When it is deposited in waterbodies (lakes, rivers and wetlands), bacteria transforms some of the Hg into methylmercury (MeHg), the most toxic form.

MeHg is bioaccumulative; each fish absorbs mercury from the smaller fish or organisms it eats. Thus, older, larger fish have more Hg in them than small fish.

2002: *"Level and Extent of Mercury Contamination in Oregon, U.S.A. Lotic Fish"*—This was the first statistically designed survey of its kind for the state of Oregon; it assessed the proportion of stream length affected by fish tissue Hg (mercury) concentrations considered harmful for human and wildlife consumption.

2005: *"A Biopsy Procedure for Determining Filet and Predicting Whole Fish Mercury Concentration"*—Non-lethal biopsy sampling is a reliable predictor of whole-fish Hg concentration. A tissue sampling procedure was used to measure Hg in filet, and then compare it with whole-body Hg concentration of the same fish. Fish were analyzed at 65 sites across 12 Western States, and a tight correlation resulted in an equation for predicting whole-body Hg concentration from Hg concentration in filets. Filet samples can be collected using a non-lethal sampling method.

2007: Holding Time Study *"Mercury Concentration in Frozen Whole-Fish Homogenates is Insensitive to Holding Time"*— The most recent research demonstrates that there is no difference in Hg concentration measured in the same frozen fish tissue sample when the analyses were done 4 years apart. This extends the acceptable fish tissue holding time for analysis from the current 28-60 day period to at least 4 years and probably longer, since there was no statistically significant change. Frozen fish tissue can be held for at least 4 years without affecting analytical results.



2007: West Stream Study *"Mercury Concentration in Fish from Streams and Rivers Throughout the Western United States"*—This was the first application of probability sampling of streams for Hg in fish tissue over a large area (12 Western States).

Salmonids (i.e., salmon, cutthroat trout) were assessed for mercury concentration in 125,000 km of stream-length. In 11% of the assessed stream length salmonids exceeded the wildlife criteria value (0.1µgHg/g). In 2.3% of stream length salmonids exceeded levels acceptable for human consumption (0.3µgHg/g). Piscivorous fish (those that eat other fish) in 31,400 kilometers of stream were also assessed. In 93% of assessed stream length, individuals exceeded 0.1µgHg/g. In 57% of assessed stream length, individuals exceeded 0.3µgHg/g.

left: map shows scope of 2007 WED study of streams in Western U.S.

In a Nutshell:

PATCH is a spatially explicit, individual-based life history simulator designed to predict how the numbers and distribution of wildlife species will change over time.

The model can predict how wildlife populations will respond to multiple interacting stressors, how population density will increase or decrease, and whether the species is likely to go extinct. It can produce maps of where the species will be found as a landscape changes with time.

PATCH ("Program to Assist Tracking Critical Habitat") is a complex, spatially explicit computer model developed at WED by **Dr. Nathan Schumaker**. The model can address diverse questions using multiple datasets to introduce various factors into each simulation.

PATCH was designed to predict the potential effects of stressors such as pesticides, pollutants and land-use changes on ecosystems, and the long-term response of various species to such stressors.

For example, habitat types, weather conditions, food sources or disease events can be added or removed to determine the effect on a population. Simulations can be used to explore the efficacy of anticipated habitat recovery efforts.

Canadian researchers, led by Dr. Julie Heinrichs, recently sought input from Dr. Schumaker to assist them in predicting the fate of the "at-risk" Ord's Kangaroo Rat (*Dipodomys ordii*).

Ord's Kangaroo Rat was once abundant in Canada's arid sandhill region.

Seeing an opportunity to work with a dataset that could test and improve the model for EPA applications, Schumaker helped parameterize *PATCH* for this use by the Canadian research team.

Under Canada's Species at Risk Act (SARA), habitat that is critical to listed animals must be identified. Mapping such habitats requires integration of habitat availability and quality, as well as a population analysis that indicates the potential future "success" of the species.

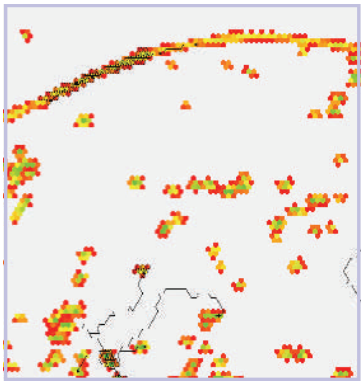
Ord's Kangaroo Rat is a nocturnal desert dweller whose energy requirement is met by a cheek-pouch load of seeds daily. It builds a complex underground burrow, and can survive for long periods without water.

This solitary animal requires an open, sparsely vegetated, sandy habitat.

Kangaroo Rats are important prey for many raptors, reptiles, and mammals, some of which are considered at risk in Alberta.

The goal of Heinrichs and her colleagues was to identify and assess habitats necessary for recovery and long-term persistence of Ord's Kangaroo Rat (K-Rat) using WED's spatially explicit population model.

While kangaroo rats in general are wide-spread in the U.S., Ord's Kangaroo Rat is listed as "at risk" in Canada's Alberta and Saskatchewan provinces due to loss of its arid sandhill habitat.



left: clusters of yellow and green hexagons represent high quality individual territories of Dipodomys ordii on this PATCH simulation map.

In the model, a simulated population of K-Rats was distributed throughout the landscape; location and movement of the individuals, and data on their overwintering, reproduction, and summer survival, were tracked through the landscape over a 50-year period. Schumaker set the model's parameters to assign habitat quality scores to pixels on a map, and then integrated them into a hexagonal grid.

PATCH may help predict what the future holds for K-Rat, and the results of this study will potentially be used as a benchmark for alternative management scenarios.

The use of WED's *PATCH* model by Canadian scientists demonstrates not only its versatility in a variety of applications, but also the value of EPA research to other nations and their agencies.

PATCH is currently utilized by EPA's Office of Pesticide Programs for ongoing research on the effects of pesticides in the environment.

Western Ecology Division scientist **Dr. James Power**, working in collaboration with the Oregon Department of Fish & Wildlife (ODFW), has been implanting "pinger" devices into juvenile fish and tracking their journeys to the sea in an effort to learn more about fish populations and migration patterns.

Determining whether or not estuarine habitats are functioning properly to support salmonid populations is necessary because, under the Clean Water Act, States must designate specific uses for their waterways, and periodically report on those waterways. In Oregon, "salmon rearing and migration" is an important designated use for many estuaries.

The downstream migration of salmonid smolts is an important phase in the fish's life cycle: the fish is under physiological stress as it transitions to the saltwater environment, and it is also at greater risk of predation. Power's study tracked the movements of migrant salmonid smolts captured in tributaries of the Yaquina and Alsea Rivers, and also hatchery-raised smolts.

Salmonids are fish in the salmon and trout family. Many salmonids hatch in freshwater, migrate to the ocean, and then return upriver to spawn in fresh-water streams.

A *smolt* is a juvenile salmonid at the stage where the fish becomes physiologically adapted to saltwater and begins its trek to its salt water environment.

right: Derek Wilson (ODFW) surgically implants tracking device into smolt. The fish are held for observation for up to a week before release.
far right: Dynamac employees Lucas Nipp and Una Monaghan also searched for fish in the Alsea River by kayaking downstream while keeping an acoustic receiver in the water to count fish.

How Do You Count Fish in a River? Jim Power and the ODFW implanted tiny transmitters in downstream-moving coho, cutthroat, and steelhead smolts at upriver locations in Oregon's Yaquina and Alsea Rivers. Acoustic receivers, which record the date, time and individual ID of passing fish, were deployed in the water along the migration route. The receivers can detect the signal from the fish at distances of up to 300 meters.

left: A rotary screw trap operated by Oregon Department of Fisheries and Wildlife. Migrating smolts that are moving downstream are captured and held by the trap, allowing ODFW to monitor the salmon populations in Oregon's coastal streams.

Summary: Smolt Movements in Yaquina & Alsea Rivers/Estuaries:

Once entering the main channel of the river, smolts generally move downstream rapidly, and spend more than half their time in the estuary reach nearest the ocean, near seagrass beds and extensive tide flats. Smolts did not necessarily enter the ocean at their first opportunity; rather some approached within a few hundred meters of the open ocean, and then moved back up the estuary.

The seagrass beds are thought to be an important habitat for these fish while in the estuary. This research underscores the importance of the estuarine habitat, and will help inform decisions that could help protect this habitat in the future.

PACIFIC COASTAL ECOLOGY BRANCH NOTES

Eelgrass is a vital element of estuarine habitats, and their growth depends on receiving sufficient light to carry out photosynthesis. If light is not sufficient, plants must utilize stored energy, depletion of which can eventually result in mortality. The minimum hours of pigment-saturating (Hsat) daylight needed by eelgrass has been estimated at 3-5 per day. However, this value has not been measured in the laboratory. Now, eelgrass harvested from Yaquina Bay, Oregon is being grown by **Dr. Bruce Boese** in 1,000 gallon indoor mesocosms and exposed to various light treatments. Results of a similar experiment last summer indicated that eelgrass was able to survive and grow if Hsat light exceeded 4 hours daily. Data will be used by **Drs. Pete Eldridge** and **Jim Kaldy** to aid in the development of a model which will predict seagrass responses to changes in light, nutrients, temperature, salinity and sediment chemistry.

Pilot experiment of eelgrass growth in mesocosms

Recently **Dr. Henry Lee II** (PCEB) was interviewed for an article in *"Ballast Exchange Newsletter"* of the West Coast Ballast Outreach Project, based at the University of California/ Davis. The interview focused on several of Henry's current projects, including the PCEIS database (which combines detailed distributional data on native and non-native species), his technical assistance to IMO (International Maritime Organization), and recently, his evaluation of an Aquatic Invasive Species theory based on biogeography.

To read full text of article, click here and scroll to pages 4-5

Ballast water

Ballast water is carried in ships to provide stability. At the ships' destination, the water is pumped out, along with any organisms it contains; these "hitchhiker" organisms can be invasive and detrimental to local marine ecosystems.

FRESHWATER ECOLOGY BRANCH NOTES

Since the mid 1990's, surplus fish carcasses have been placed in Pacific Northwest streams and rivers in an effort to boost nutrient levels needed by wild juvenile salmon. To determine how over-wintering juvenile salmon utilize nutrients, **Dr. Robbins Church** has developed an approach for analyzing **stable isotopes** of carbon and nitrogen in fish mucus, a rapidly-changing "tissue" not previously analyzed for isotopes. At the Oregon Hatchery Research Center, Church and colleague **Dr. Joseph Ebersole** are conducting feeding experiments under controlled conditions and measuring the relative rates of isotopic change in mucus vs. muscle tissue. The data in this groundbreaking study will complement data collected from wild fish, and will help evaluate restoration strategies that may benefit wild salmon throughout the region.

What is a Stable Isotope?

The element carbon, for example, has 6 protons in its nucleus, but the number of neutrons (6, 7 or 8) determines the atomic mass and the specific isotope.
When carbon is passed from one system to another (as from a food source to the tissue of an animal) there is a slight preference for either the heavier or the lighter isotope, so the ratio changes, producing a distinctive isotopic "fingerprint".

In June 2006, the US Supreme Court ruled in two cases concerning jurisdiction under the Clean Water Act (CWA). The decisions, which deal with CWA jurisdiction of non-navigable streams and adjacent wetlands, have increased the need for scientific information to inform future policies and legislation.
In a recent journal article, **Drs. Scott Leibowitz** and **Jim Wigington** propose an approach for addressing these science needs.

In summary:

- Addressing the science needs prompted by the Supreme Court cases requires that the various waters be regarded as components of integrated hydrological and ecological systems.
- Leibowitz and colleagues define metrics of hydrological permanence and significant nexus.
- Applying these metrics could help implement the new legal standards during jurisdictional determinations.

Significant Nexus

refers to the effects of non-navigable streams and adjacent wetlands on the chemical, physical and biological integrity of navigable waters.

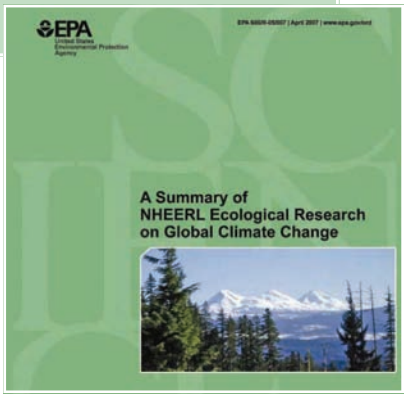
ECOLOGICAL EFFECTS BRANCH NOTES

There is a growing appreciation for the importance of soil carbon to ecosystem productivity and as a reservoir for carbon, yet our understanding of soil carbon stability and distribution is limited. Soil carbon comprises about 75% of all terrestrial carbon, however, current soil carbon maps are inadequate in representing these stocks, which are vulnerable to loss, as part of a *dynamic* carbon cycle. An improved inventory and monitoring approach is needed to assess not only its distribution, but also its stability in a changing environment. **Dr. Mark Johnson,** a Soil Scientist at WED, has been invited to serve on the Scientific Steering Group of the National Soil Carbon Network. This network is a collaborative effort to produce high-resolution information on soil carbon stability and distribution of soil carbon. The sequestration of additional carbon in soil may reduce atmospheric carbon loads and help to mediate the effects of climate change.

Soil: a key life support system

BEYOND WESTERN ECOLOGY DIVISION

The report, *A Summary of NHEERL Ecological Research on Global Climate Change*, spans 14 years of research conducted by EPA/Office of Research and Development at its National Health and Environmental Effects (NHEERL) research facilities. Edited by **Drs. Peter Beedlow** and **David Tingey**, the compendium presents findings on how global climate change may affect terrestrial, freshwater and marine ecosystems as well as agriculture. This research has provided a better understanding of the potential effects of global warming and rising levels of atmospheric CO_2 on natural and managed ecosystems.



left: At WED's mesocosm facilities, Kristy Mathes (with clipboard) of Terrestrial Ecosystems Research Associates (TERA) gives a tour of the Asymmetric Warming experiment.

Preliminary results from the DOE/EPA cooperative agreement study on asymmetric warming conducted by **Dr. Jillian Gregg** (TERA) show that grassland mesocosms exposed to asymmetrically elevated temperature treatments (+5ºC daily minimum / +2ºC daily maximum) had substantially higher respiratory costs in response to the warmer night temperatures. However, assimilation also increased in response to warmer mornings and milder midday temperatures, resulting in no biomass difference when compared to symmetrically elevated temperature treatments.

The question now is whether vegetation in the asymmetric treatments will grow more in response to longer growing seasons. The experiment will also look for changes in species composition and abundance, and determine if there are changes in flowering times in response to the altered temperatures. The study continues through June, 2010.

Invasive zebra mussels and quagga mussels (Dreissena polymorpha and D bugensis) have been aggressively spreading in many U.S. waterways. Now, a team of researchers, including Western Ecology Division scientist **Dr. Paul Ringold**, have created an ecoregion "risk" map based on calcium concentrations, to determine where the mussels could successfully invade. Primary data were taken from surveys made by the U.S. EPA's Environmental Monitoring and Assessment Program, and Wadeable Streams Assessment. The map can help determine where resources should be targeted for management of the invasives.

above: Zebra mussels compete with native species, and can clog pipes and other municipal water infrastructure.

BEYOND WESTERN ECOLOGY DIVISION

Australia: **Dr. Mark Johnson** attended the 3rd International Conference on Mechanisms of Organic Matter Stabilization and Destabilization in Soils and Sediments to give a presentation and to work with Australian colleagues on soil assessment methods. Johnson also met with the Australian scientist who shares one of his own research interests: the effects of manufactured nanomaterials on the environment. One of the expected results of the Conference is information sharing and possible collaborations.

Brazil: **Dr. Phil Kaufmann** was invited to the Universidade Federal de Minas Gerais (UFMG) in Brazil to do research and teaching in connection with the Manuelzao Project, which includes development of biomonitoring of water quality, physical habitat and aquatic biodiversity of the Velhas River watershed. The Brazilian monitoring community has been interested in the integrated approaches of Environmental Monitoring and Assessment Program (EMAP), which they learned of on EPA's web site. Dr. Kaufmann's visit will provide the foundation for national biomonitoring in Brazil.

China: **Dr. Walt Nelson** attended the 2nd Global Conference on Large Marine Ecosystems (LME's) in Qindao, China in September. On the agenda were monitoring, assessment and management of marine resources and ecosystem health, impacts of climate change on LMEs, socioeconomics and valuations of LMEs, assessment of the impacts of climate and anthropogenic factors, and cooperative global programs for action.

France: **Dr. John Stoddard** attended the 23rd Task Force Meeting of the International Cooperative Programme (ICP) on Assessment and Monitoring of Acidification of Rivers and Lakes in Nancy, France. Eighteen European countries, the US and Canada supply data on acidification to a central database; analysis of the data provides an understanding of long-range transboundary air pollutants, heavy metals and organic pollutants. The project demonstrates the benefit of international agreements to reduce emissions of pollutants.

India: **Dr. Kristina McNyset** attended the Joint Workshop on Ecological Forecasting in Pune, India in August. The workshop addressed the rapidly evolving discipline of ecological forecasting. The meeting exposed Indian scientists to U.S. advancements in ecological forecasting; brainstorming common areas of interest led to collaborative work programs and a framework for an Indo-U.S. Virtual Centre for Ecological Forecasting.

United Kingdom: **Dr. Chris Andersen** attended the September SETAC Conference on Environmental Effects of Nanoparticles and Nanomaterials in London. While production of nanomaterials is expanding rapidly, their effects on the environment remain in question. Meeting highlights included: properties of nanoparticles in the environment; detection and bioassays for nanosubstances; and environmental and industrial applications of nanotechnologies. Also discussed were regulation, and policy issues.

above: Freshwater Ecology Branch Chief Dr. Tony Olsen (left) and Dr. Kuegel at WED

Dr. Benno Kuegel , a biologist with the Bavarian Ministry of Environment's Agency of Water Management in Germany, spent two months at WED in Corvallis during 2007 working with Western Ecology Division scientists and learning about WED's freshwater assessment methods. Dr. Kuegel also shared information about sustainable water management practices in Bavaria.

above: Qindao, China—a junk (traditional Chinese sailing vessel) in Qindao. Photo courtesy of Walt Nelson

above: Pune, India—local women created sand mandala on floor of hotel lobby to celebrate a festival. Photo courtesy of Kristina McNyset

"NANO" MAKES BIG NEWS

Engineered nanoparticles have the potential to be used in every sector of the economy, including consumer products, health care, energy, and agriculture, and to improve how we monitor, manage, and minimize contaminants. By 2014, 15% of all goods manufactured globally could involve nanotechnology; there are already nearly 600 such products in the marketplace including clothing, cosmetics, and medicines.

Although the EPA is interested in the possible benefits of **nanotechnology,** it also has the mandate to protect human health and the environment, and to date, there is almost no information on the effects of engineered nanomaterials once they reach the environment.

To address this information gap, WED has initiated a new project, being led by **Drs. Chris Andersen, Mark Johnson** and **Paul Rygiewicz,** to examine the potential effects of engineered nanoparticles on terrestrial ecosystems. They recently developed a three-phase research approach. In Phase I, traditional OPPTS testing protocols will be examined to determine their adequacy in assessing the toxicity of nanoparticles.

In Phase II, mechanisms of toxicity will be explored and novel approaches based on proteomics and genomics for rapidly assessing toxicity will be evaluated.

Finally, *Phase III* will focus on the degree to which nanoparticles released into reconstructed ecosystems represent a risk to ecosystem structure and function. The unique aspect of Phase III is shifting the endpoints of interest from individuals to groups of individuals, and to their interactions and system level responses.

This research will assist EPA OPPTS' development of regulatory requirements, including pre- and post-registration product assessments and monitoring. In addition, the results will allow other Agency offices to identify potential environmental concerns resulting from nanoparticle exposure. Finally, the results will enable the Agency to evaluate its current risk assessment framework, and may lead to the development of a new assessment framework should the current approaches be inadequate for nanoparticles.

Nanotechnology...

...or molecular "manufacturing", allows researchers to alter material properties to create new materials and products.

The "novel" properties of nanoparticles are different from the properties of the bulk material.

For example, your new bedroom slippers could have a silver lining—literally—of material containing silver nano-particles, which have antibacterial and antifungal properties.

One nanometer =1 billionth of a meter

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The Last Word: Seeking Public Opinion on Rodenticides

Recently 9,000 questionnaires were sent to households and businesses in California as part of **Dr. Anita Morzillo's** "Rodenticide Use" survey. Morzillo is a cross-NHEERL post doctoral researcher working on sustainability issues at the Western Ecology Division; she has been working on the project since November 2005.

The survey was done in collaboration with the National Park Service and California State University/Stanislaus, and will help assess public awareness of the potential effects of rodenticide use on wildlife. The information will benefit land managers by giving insight into environmental decision-making by individuals.

below: Dr. Morzillo loads some of the surveys that were mailed to households and businesses in a target area of California.

Scientists featured in this Research Update work at EPA's Western Ecology Division (National Health & Environmental Effects Laboratory) unless otherwise noted.
For more information please contact editor Joan Hurley: hurley.joan@epa.gov

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